International Journal of Mechanical and Production
Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 8, Issue 2, Apr 2018, 355-362

MECHANICAL CHARACTERIZATION OF PURE ALUMINIUM OXIDE (AL_2O_3)

YATHISH NARAYANA RAO. K. N[1] & K. MOHAMED KALEEMULLA[2]

[1]Associate professor, Department of Mechanical Engineering, SJCIT, Karnataka India

[2]Associate professor, Department of Mechanical Engineering, UBDTCT, Karnataka India

ABSTRACT

The mechanical and physical properties of engineering Alumina ceramics (Al_2O_3) have been reviewed from literature data for the purpose of characterizing the mechanical response of Alumina to sintering manufacturing processes in engineering applications. The aim of the current investigation is the study of microstructure, mechanical, physical and tribological properties of alumina by sintering. The aluminium oxide powder is mixed with polyvinyl alcohol and is pressed in cold iso-static press to form green product, Mechanical properties of the AMMCs developed has been investigated using Vickers Hardness test rig, Impact strength test rig, UTM (Universal Testing Machine), compression

KEYWORDS: Alumina Ceramics (Al_2O_3), Mechanical Response of Alumina & UTM

Received: Dec 20, 2018; **Accepted**: Jan 10 2018; **Published**: Mar 02, 2018; **Paper Id**.: IJMPERDAPR201839

Original Article

INTRODUCTION

Alumina is one of the most cost effective and widely used material in the family of engineering ceramics. The raw materials from which this high performance technical grade ceramic is made are readily available and reasonably priced, resulting in good value for the cost in fabricating alumina shapes. With an excellent combination of properties and an attractive price, it is no surprise that fine grain technical grade alumina has a very wide range of applications.

Comparison of Material Properties of Generally used Industrial Materials

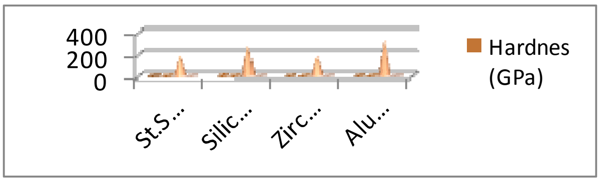


Figure 1.1: Clustered Cone Chart Represents the Mechanical Properties of the Materials

Table 1: Comparison of Material Properties

	Hardness (Gpa)	Comp. Strength(GPa)	Young's Modulus(GPa)	Specific Gravity (Bulk density *10^3 kg/m^3)
Stainless Steel	2.3	0.91	205	8
Silicon Nitride	20	3.90	300	3
Zirconia	13.5	1.20	200	6.3
Alumina	15.6	2.23	360	3.8

Isostatic Pressing

Figure 1.2: Isostatic Pressing Machine

Types of Isostatic Pressing are as Follows

- Hot Isostatic pressing.
- Cold Isostatic pressing.
- Specimens are prepared based on Sintering temperatures
- Specimen 1 : 1350°C
- Specimen 2 : 1400°C
- Specimen 3 : 1450°C

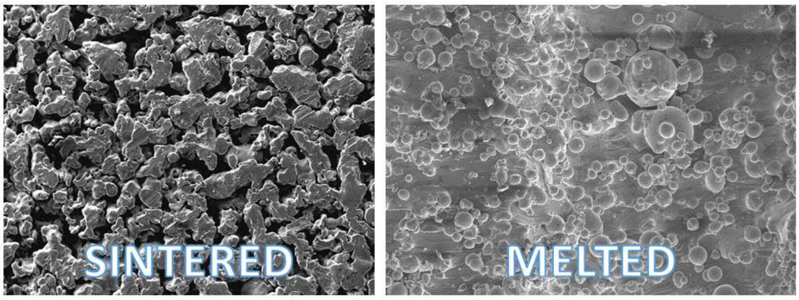


Figure1.3: Difference between Sintering and Melting

OBJECTIVES

- To study and understand the properties of commonly used industrial materials.
- Casting of the Alumina by Cold Iso-static pressing and Sintering.
- Preparation of the specimen as per ASTM standards.
- Study of the test material for mechanical properties and documentation of the same.

Flow Chart

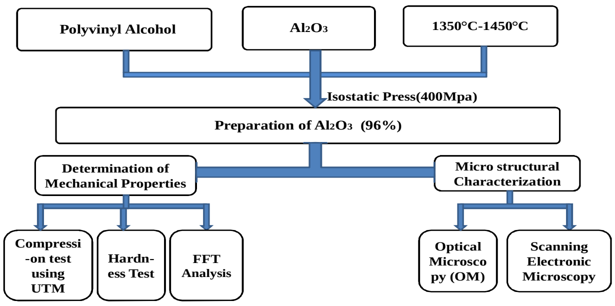
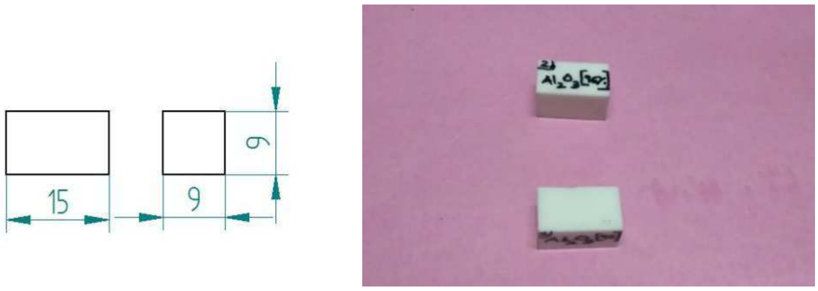


Figure 1.4: Flowchart of the Project

EXPERIMENTAL SET-UP AND METHODS

Hardness Test Specimen

The hardness specimen dimension 15mm length and 9mm square face its follows ASTM standard with the aspect ratio 1.66 (l/d ratio) is as shown in figure 1.5.



(All dimensions are in mm)

Figure 1.5: Hardness Test Specimen

Vickers Hardness Test

The Vickers Hardness number is obtained by applying a load of 3 Kg for the 10 Sec time with Metatech diamond point indenter of on flat composite specimens.

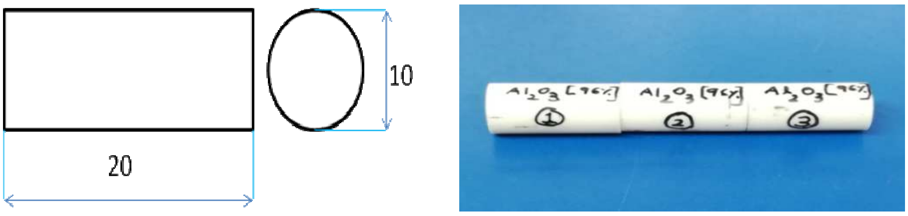
Figure 1.6: Vickers’s Hardness Tester

Compression Test

Compression tests are conducted on the UTM machine (figure 1.8) which conforms to ASTM standards, which are prepared from the EDM cutting process as for the standards of length 15mm and square edge 9mm. The edge of the specimen is given a smooth finish with abrasive paper.

Figure 1.8: Universal Testing Machine (UTM)

Compression Test Specimen



(All dimensions are in mm)

Figure 1.9: Compression Test Specimen

Experimental Modal Analysis using FFT Analyzer

Figure 1.10: Actual FFT Experimental Set up System with Chasis

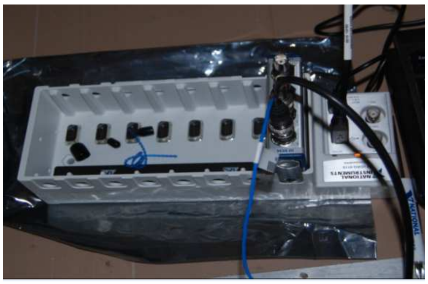
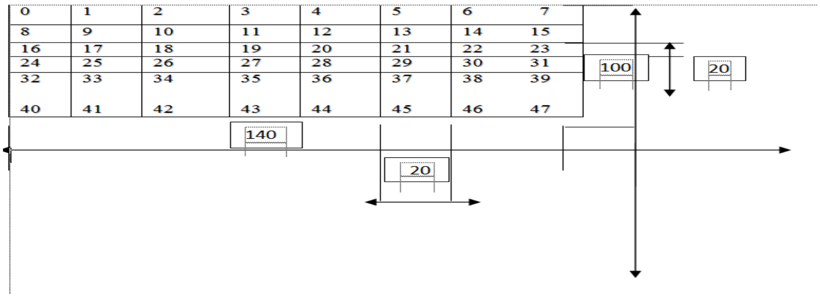


Figure1.11: Data Acquisition (DAQ)

FFT Analysis Specimen: Grid Preparation on Specimen



(All dimensions are in mm)

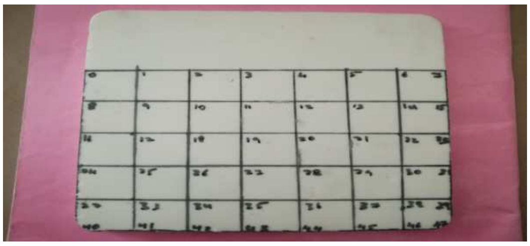


Figure 1.12: Fast Fourier Transform Specimen

RESULTS AND DISCUSSIONS

Hardness Test

Hardness test is conducted using the Micro Vickers hardness tester machine in the room temperature. Here 10N force is applied for 10 sec and the data on two specimens at different positions are tabulated in the table 4.1. Hardness of the specimen was recorded at three different locations.

Table 2: Results of Hardness Test of Al_2O_3

Specimen	Trial No.	Load(N)	Time(Seconds)	Vickers Hardness (HV)
1	1	10	10	1424.9
1	2	10	10	1633.4
1	3	10	10	1374.0
2	1	10	10	1381.6
2	2	10	10	1368.4
2	3	10	10	1345.6

From the table 4.1, we could see that the hardness varies with the different specimen and also at different positions at which the indentation takes place in the specimen and also hardness varies due to the material toughness with the increasing of particulates and the mechanical defects also increases, because due to the variation of sintering temperature such as porosity, shrinkages etc.

Compression Test

The Compression test was conducted at room temperature on the specimens. The experiments are repeated twice and average readings were computed and presented in table. The table below shows the results of compression test between load verses length and also shown in the graph (Figure 1.13)

Table 3: Results of Compression Test of Al_2O_3

SNo.	Length in [mm]	Load in [N] (1)	Load in [N] (2)	Load in [N] (3)
1	0	9	7	8
2	0.5	3484	4080	8114
3	1	10937	13718	20284
4	1.5	20529	26268	33535
5	2	31378	39401	46920
6	2.13	34748	43327	50582

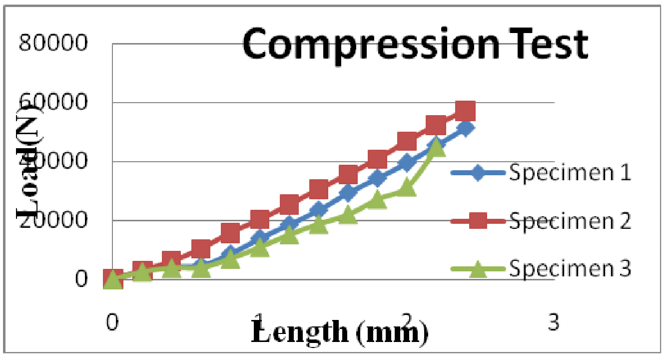


Figure 1.13: Compression Test (Load v/s Length)

The Compression test was conducted at room temperature on the specimens. The experiments are repeated twice and average readings were computed and presented in table. The table below shows the results of compression test between stress verses strain and also shown in the graph (Figure 4.2)

Table 4: Results of Compression Test of Al_2O_3

SN.	Strain	Stress in [N/mm²] (1)	Stress in [N/mm²] (2)	Stress in [N/mm²] (3)
1	0	0.05	0.11	0.12
2	2	52	78	49
3	4	108	200	91
4	6	237	322	194
5	8	373	453	280
6	10	501	598	400

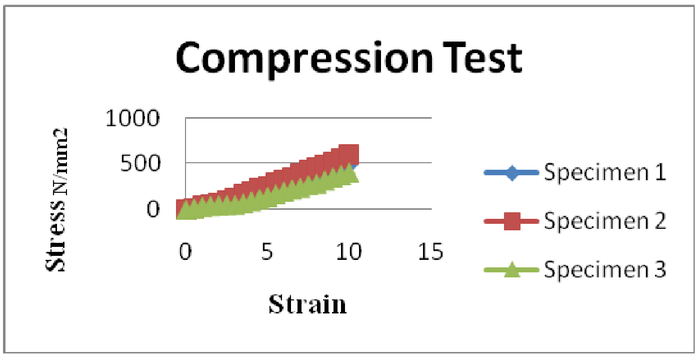


Figure 1.13: Compression Test (Stress v/s Strain)

Table 5: Results of Compression Test of Al_2O_3

Sl No		Specimen 1	Specimen 2	Specimen 3
1	**Peak load (N)**	34747.02	52719.82	82188.18
2	**Break load (N)**	21598.97	52718.94	52719.82

Fast Fourier Transform Analysis

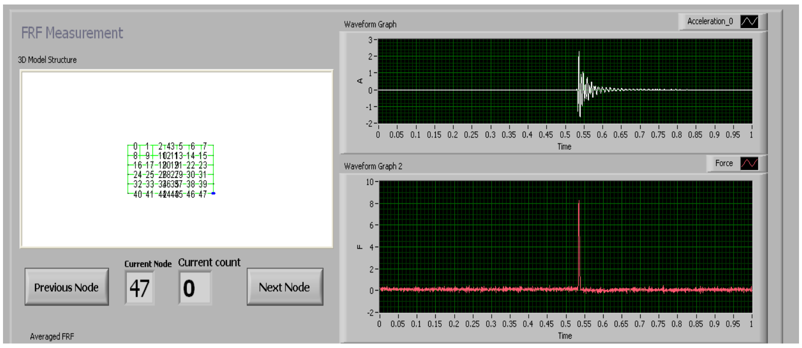


Figure 1.14: Nodes Arrangement

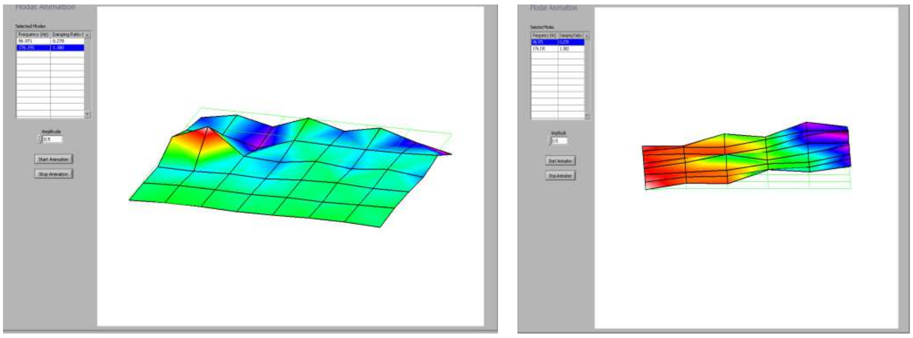


Figure 1.15: FFT

Bending **Twisting**

Structural vibration analysis is a multifaceted discipline that helps increase quality, reliability and cost efficiency in many industries. Analyzing and addressing structural vibration problems require a basic understanding of the concepts of vibration, the basic theoretical models, time and frequency domain analysis, measurement techniques and instrumentation, vibration suppression techniques, and modal analysis.

CONCLUSIONS

The project is carried out using Al_2O_3 to study the microstructure and mechanical properties of Al_2O_3 processed through Cold press and Sintering. From the results, conclusions are made as follows:

- The Al_2O_3 was prepared by Cold pressing it with Poly vinyl alcohol (PVA) followed by Sintering
- The FFT analysis reveals that bending is more as compared to twisting in the material(Al_2O_3)
- The study of mechanical characterization reveals that upon adding the PVA, there is an increase in the hardness and compressive strength of the material (Al_2O_3)
- The microstructure study reveals that the particles of Al_2O_3 with PVA have an irregular shape distributed randomly.
- Also, the presence of Carbon in least quantity represents the evaporation of the binder material during sintering.
- The presence of impurities such as Ca, Si, Mg and Carbon particles in the Al_2O_3 leads to decrease in property such as compression strength but increases in hardness of the material.

SCOPE OF FUTURE WORK

- The present investigation is conservative about adding the PVA binder to Alumina. Similarly, use of other organic binders, such as Carboxy Methlyl Cellulose, Polyethylene Glycols, Lignosulfonates, Dextrin etc., or inorganic binders, such as Sodium silicate, Magnesium alumium silicates, Bentonite etc., with Al_2O_3 can be carried out to study the mechanical characterization.
- Along with $Al_2O_{3,}$ using a matrix and in forcing any other material gives us the Ceramic matrix composite material and characterization of the same may grant the replacement of currently used materials.

REFERENCES

1. *M K Surappa - Aluminium matrix composites: Challenges and opportunities, Vol. 28, Parts 1 & 2, PP. 319–334, 2003.*
2. *S.N Prashant, Madev Nagaral and V Auradi - Preparation and Evaluation of mechanical and wear properties of Al6061 reinforced with graphite and sic, Int. J. Mech. Eng. & Rob. Res. 2012.*
3. *S .N Prashant, Madevanagaral and V Auradi - Optimization of surface roughness on turning fibre-reinforced plastics (FRPs) with diamond cutting tools, Int. J. of Advanced Manufacturing Tech, PP. 319–323, 2005.*
4. *Gracious Ngaile1 and Kuhlman, G.W, Bulk Forming ASM Handbook, ASM International, Materials Park, OH, Vol. 14A, and PP. 299–316, 2005.*
5. *Kora T Sunny, Joby Joseph, Georgekutty S Mangalathu & Jeeno Mathew, A Review on Mechanical & Microstructural Property Evaluation of Aluminium 5083 Alloy WeldmentInternational Journal of Mechanical and Production Engineering Research and Development (IJMPERD), Volume 3, Issue 4, September - October 2013, pp. 119-128*
6. *B. M. Viswanatha, M. Prasanna Kumar, S. Basavarajappa, T. S. Kiran "Mechanical Property Evaluation Of A356/Sicp/Gr Metal Matrix Composites" Journal of Engineering Science and Technology Vol. 8, No. 6 (2013) 754 – 763 © School of Engineering, Taylor's University*
7. *J. Onoro, M.D. Salvador, L.E.G. Cambronero, "High-temperature mechanical properties of aluminium alloys reinforced with boron carbide particles" Materials Science and Engineering A 499 (2009) 421–426*